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BOSTON UNIVERSITY

GRADUATE SCHOOL

Thesis

A PRACTICAL TEST OF THE STANDARD MINIMUM COURSE IN CHEMISTRY FOR HIGH SCHOOLS

Submitted by

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(B. S.; Dartmouth 1907)

In partial fulfilment of requirements for
the degree of Master of Arts

1926.

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A PRACTICAL TEST OF THE STANDARD MINIMUM COURSE IN CHEMISTRY FOR HIGH SCHOOLS.

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A PRACTICAL TEST OF THE STANDARD MINIMUM COURSE IN CHEMISTRY FOR HIGH SCHOOLS

INTRODUCTION

The work in Chemistry in the early days of the secondary school was radically different in content and method from that of the present day; especially when compared with the topics of the standard minimum course.

Going back to my own high school days, and to the textbooks indicated below it is evident that time has wrought many changes which presumably have been for the good of the greatest number.

Cooke, J. P. Jr.-The New Chemistry. D. Appleton & Co. 1881.

Remsen, Ira.-An Introduction to the Study of Chemistry.
Third Edition-Revised. Henry Holt & Co. 1893.

Remsen, Ira. Seventh Edition-Revised " 1906.

Hessler-Smith. Essentials of Chemistry.
Benj. H. Sanborn & Co. 1902.

It will be easiest to note the progressive changes if we begin with the oldest source available, which is that by Cooke. In his preface he states that this is a series of "lectures delivered before the Lowell Institute in the autumn of 1872." These were based on the Law of Avogadro, planned for an "intelligent but not professional audience," many of whom had studied chemistry under the dualistic (?) system; the object being to point out the "chief characteristics by which the new Chemistry differed from the old." Even then, the laboratory method was knocking at the door, for he apologizes for the shortcomings of the course in this way,-"Conscious that any description of experiments must

INTRODUCTION (continued)

necessarily fall short of giving that force of impression which the phenomena of Nature produce when they speak for themselves."

His opening lecture was upon "Molecules and Avogadro's Law," and is a larned discussion of the law and of changing theory. He cites Dr. Turner's works of the Civil War period, in which the "Nomenclature was simple and beautiful." It is essentially "*physical chemistry*" such as might precede a course in radio and electrons today; but the terms are archaic, as for illustration when he speaks of a *magic lantern*, the interstices in a piece of glass, and the power of elasticity as a million square. Next he considers the wave theory of light, which no one would think of putting at the beginning of a course in chemistry today.

The second lecture covers the "Gas Laws", and then procedes to correlate molecular structure with the effects in polarization of the Nicol prism and of the magnetic field. Then he discusses the weight of the molecule, referring all to the "*crith*" or the weight in vacuo of one liter of hydrogen. He offers the same arguments for a use of the metric system that we hear today, and yet we still follow blindly the English system.

In succeeding lectures he considers with mathematical precision the analysis of sugar and water by means of oil of vitriol and the electric current; the atomic theory; the Law of Definite Proportions using the well known iron and sulfur experiment; the fact that there are known *63* elements; atomic weights and symbols, the reactions involved in the making of salts and the baking

INTRODUCTION (continued)

powder equations; classification of chemical changes; combustion and explosives; alkalies and acids; electro-chemical theory; and synthetic organic compounds.

Throughout, the book has a most pleasing style, and the experiments would hold the attention of any audience; yet it is so mathematical and devoid of correlation with life as to be a philosophy rather than a usable science. As he says in his sixth lecture, "Our modern science is a philosophical system, based on ideas distinctly stated and consistently developed--we are on the right path, and making the only satisfactory progress."

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REMSEN

Twelve years later, Ira Remsen declared that it is his belief that "it is better to dwell longer on a few subjects provided these subjects are properly selected;" thus sounding in advance the present plea for less ground to cover and more correlation with life.

Two mistakes are commonly made he says,-first of teaching theory too early, and second, of calling for laboratory work without telling the pupil what to do, and where to expect results. He favored careful laboratory work, and his book is a combination of descriptive matter and laboratory directions.

It is strong on the metals, some 93 pages being given to a detailed discussion with numerous qualitative experiments. In the seventh edition there is added a section on the theory of solutions, because of recent discoveries. The experimental matter is still

INTRODUCTION (continued)

incorporated with the main text, and this has been a cause for criticism, because it is hard to tell whether the pupil or teacher is to do the work.

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HESSLER-SMITH-1902

For the first time, the laboratory work is put in a separate section, bound with the main text, A teacher's handbook is issued as a special folder. Thus the laboratory course is seen coming into its own. But there is no mention made of "Organic Chemistry"; one of the most fruitful topics today.

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(The writer took his high school chemistry in 1901-02, and has nothing but a notebook to remind him of the work done. On the strength of the course he passed his examinations for college, and is teaching chemistry today.)

From the time when I entered Dartmouth in 1903 until 1913-14 when I shifted my teaching emphasis from Botany, Zoology, and Physics, to Chemistry I was not vitally interested in Chemistry and so lost my step. From that time on, however, I have been in charge of science work--until 1918 in charge of all branches,--since then of chemistry, general science, and physiology. Such points as I may make are therefore part of my experience, colored by local and world conditions. I am so immersed in the work that I may lack perspective, and have tried many different orders of topics. Some topics get no response at all, and others have always enlivened the course.

INTRODUCTION (continued)

The trend today seems to be to go back a bit and lay the foundation for the rapid advances in radio, and all other new knowledge. This is, I think, as it ought to be; and in a score of years more we may know what is best for a beginner in Chemistry. It is my contention that this "Minimum Course" is the best effort yet to that end, and the results obtained this year (1926) in the face of outside competition, prove it. The three honor parts have gone to pupils who have had a year of Chemistry.

This past year-1925-26--I have made in my regular work at the Salem Classical and High School a definite test of the Standard Minimum Course, as outlined in Appendix B, changing the order of the topics somewhat to meet local needs, and correlating at every point with life as the pupil sees it. The results have been good, I believe, and should furnish a foundation for both college work and life.

SECTION A
DIVISION I REQUIREMENT AND COLLATERAL READINGS

The requirements of the C. E. E. B. as listed at the present time are so extensive that it has been absolutely impossible to cover them in the time allotted in the school program, and therefore it was with no small feeling of satisfaction that I began to try out this "Standard Minimum Course."

The twenty eight topics as given in Appendix B (Q. V.) together with the two supplementary sections have been taken in the order indicated on Pages 19-20 up to April 8th of the present year of 1926; at which time two days were taken for the third quarterly examinations. From then on the work has been planned to agree with the outline as given, as far as possible.

Every topic has been correlated with some local condition, a newspaper headline furnishing the clue, or a first page article; a report from some government bureau, the work of the local gas company, where the superintendent and head chemist are former pupils of the writer; the Hygrade Lamp factory, the tanneries, pottery, cotton mills, bleachery, the Lever Bros. Soap Factory in Cambridge, and any other source that we could uncover.

The writer has been fortunate enough this year to have an opportunity to try out parts of this course on a Senior Class in Physiology, half of whom were also taking Chemistry. These pupils were given some of the best topics for correlation as part of their first course, and when the topics came up in Chemistry they were given advanced problems. This has proved to date

a successful venture, and more work will be done during the spring. (We advocate in our course of study that a pupil taking Physiology should also elect Chemistry; but it is not required.)

Many of these pupils are to train for teaching or nursing, and will go to the local Normal School or the Hospital for their graduate work. The Hospital is a five minute walk from the school, and has been most willing to co-operate in any way possible, such as the loan of X-Ray films, and an oil immersion microscope lens; and the writer has for the last four years given the probationers at the hospital their course in Chemistry.

Thus in brief outline the reader has a perspective of my field of operations and is ready for more detailed statements of the results. These are grouped under the proper heads, then summarized, and an attempt made to arrive at a fair conclusion, based on the evidence available up to the time limit of the thesis. (April 30, 1926)

The literature bearing on the subject of the changes advisable in the present course in Chemistry is listed in Appendix A, and my reader will find there in full the several recommendations.

These all point to one firmly established fact; namely that the present work is not satisfactory to either teacher or pupil; and that some radical changes should be made. I am listing here merely for immediate reference the book by Twiss on "Science Teaching"; one on "Subject Matter of High School Chemistry" by Powers of Columbia; parts of an extensive bibliography by Earl R.

Glenn and Josephine Walker of Teachers' College; and the following pamphlets:

Mass. Department of Education

Bulletin (1924-#5)---Whole Number 151

1. Manual for High Schools
   (By Commissioner Smith, F. W. Wright, and F. P. Morse.)

U. S. Department of the Interior.

2. Bureau of Education

   Bulletin-1920 No. 26

   Reorganization of Science in Secondary Schools.

U. S. Department of the Interior

3. Bureau of Education

   Bulletin #35 (1918)

   Cardinal Principles of Education

DIVISION II

Analysis of the present enrollment with reference to Age, Environment, Equipment, Local Industries.

The age of the present Senior or Junior is, I think, too young to get the best results, but has been caused by some officials who would hurry school life by omitting the ninth grade and substituting nothing else. From yearly nineteen years of observation, I have come to the conclusion that the present Freshman is too young mentally to get the best results for himself, and in the end become a Senior who can satisfy the demand of the College Entrance Examination Board. Either requirements must be lowered

as this paper maintains, or else a fifth year must be given to college preparation. (In many cases, pupils have fitted at Andover, Exeter, or some special school in Boston.) The Senior of today approaches his work in Chemistry with too weak a training in Mathematics. Where the course should be a clearing house of real talent, it is in many cases an abbatoir where the inefficient fall by the sudden blow of applied mathematics; and yet in these cases with a lowered requirement most of them would graduate,--because there would be a minimum requirement for the poorest and a variable maximum for the best.

The environment of the above pupils is that of a city of 43,000 on one of the best harbors of the Atlantic coast; a center of a diversified industry, fostered and advertised by a live wire Chamber of Commerce; getting ready to celebrate its 300th Anniversary this summer; a Mecca for the tourist; and now on one of the busiest traffic routes in the United States according to figures of a zoning expert. Its industries are largely of the sort requiring intense division of labor, and this has brought in during the last score of years a foreign population which today is in the majority. They have crowded our evening schools, at first under compulsion; have monopolized our parks and playgrounds; and become in one generation the element to be reckoned with in every city election. Those in the high school have been, in many cases, the brightest pupils, and with no background at all

in common with our "native born" are a problem in themselves. But these same pupils are going on to the colleges, making their grades, and returning to take up law, medicine, and engineering. They must be instructed for their day and generation, and if Cardinal Principles of Education is to be accepted the emphasis must be changed. VERILY, "The old order changeth, giving place to new,--And God fulfills Himself in wonderous ways."

EQUIPMENT

The Salem High School is a modern three story brick building, erected in 1908-1909, with some forty rooms, eighteen of which are on the third floor, and of which eleven have been used for science classes of the several types. Today crowded conditions have deprived us of the Botany laboratory and the Lecture Hall.

The original plan was to have all four years of the high school in this building for the morning session,--when the enrollment was under seven hundred. Now for the last four years it has been necessary to run a morning session for Seniors and Juniors, and a part of the Sophomores; while the P. M. session, equally large, has had shortened periods.

Under these conditions a single large laboratory handles one hundred and twenty-five pupils, in spaces meant for fifty-four; there are six classes--three to an instructor--which means one or more laboratory experiments every day in the week.

SECTION A
DIVISION II

EQUIPMENT (concluded)

This room has also been used for the Physiological Chemistry, and in the afternoon for the demonstrations in General Science. Half the recitation work is done in this room, the rest in a regular recitation room across the hall. The afternoon when it is free has been used for the college classes in quantitative work.

There is a large lecture table equipped with suction fan, vacuum and air pressure, hot and cold water, high pressure steam, gas, and electricity. Three laboratory tables with 16 lockers each accomodate the pupils with extra spacea about the sides of the room, for electrical experiments or storage. There are drying hoods, steam hodds, and nine regular gas hoods.

A supply room, an apparatus room, a motor pump room,--which furnishes vacuum or pressure to the lecture tables and to the pupils' tables-and a lecture room-now used as a home room; together with storage rooms and a dark room complete the material equipment.

CO-OPERATION OF LOCAL INDUSTRIES

The local industries have been glad to co-operate with our chemistry classes, and it is now a regular part of the course to visit the Gas Works, where a former pupil--now Superintendent--takes time to explain in detail how both water gas and coal gas are made. Then the Chemist at the plant is ready to tell his side of the daily routine, and to loan pieces of apparatus. (He too

is a former pupil.) They have supplied us with Ammonical liquor, and samples of coal in process.

A large lamp manufacturing concern--The Hygrade Lamp Co.- has this year loaned us slides of the work at the plant, and given about thirty pupils a chance to see the lamps in the processes of manufacture.

An oil refining business, has furnished us samples and the local gasoline stations can be called on for gasoline to test out.

The management of the daily paper is ready on short notice to show any small groups the work of getting the copy ready, and the actual preparation of a city paper.

DIVISION III ------ THE LENGTH OF SCHOOL YEAR IN THEORY AND FACT

There has been for a number of years a feeling that the colleges were expecting far more than could be done in our limited time and the following facts will strengthen these feelings, I venture to assert that conditions throughout the state are much like those locally.

The city pays its teachers for 40 weeks of school or two hundred days. During that time the people suppose that the teacher is teaching--that is, engaged in active instruction. The colleges demand of the Chemistry candidate forty weeks of work, or in other words, not less than forty laboratory exercises, suitably done and recorded; "selected from a list of sixty or more, not very different from the list below."

SECTION A
DIVISION III

This list has several quantitative experiments altogether too complex for the entire membership of a class, and requiring too much expensive apparatus. This means that the work must be done in extra periods, and for years in this school it has been the rule to call the college preparatory pupils back for afternoon work, beginning about January 1, and every two weeks until the assignments are covered; which means until it is time to start taking practice examinations.

The number doing this extra work has risen steadily until now about 40 are back, in two groups under two instructors; this year on alternate Thursdays. (We are asking the Normal School candidates to do the same work as those who are to take the examinations or be certified to college.)

The above states the theory of the requirements of the Colleges. It also indicates what the city presumes to get out of its teaching force. The facts of the case are tabulated below, for a period of 12 years, beginning in the school year 1914-1915, and concluding with the work done up to February 19 of the present year.

The school year runs from September 1 to July 1.

Out of the forty weeks are taken in September-Labor Day and the following Tuesday; October-Columbus Day; November-County Convention, two days for Thanksgiving; December-two days preceding Christmas; January-New Year's Day and one for storms; February-Washington's Birthday, and one or more storms; March-vacation week; April-Good Friday and Patriot's Day; May-Memorial Day; June-Circus Day, and Bunker Hill Day.

SECTION A
DIVISION III

This means that we average two weeks short on account of holidays that are scheduled, or because of storms. To this needs to be added special holy days in the fall and spring for the Jewish pupils, which means a loss for them, although the school is in operation. Then further two days are taken every ten weeks for examinations,--eight days in the course of a year, or a week and a half when no instruction is given. And finally the demand for special assemblies, and extra curricula work destroys an equivalent of one week more in the course of a year.

The most casual reader can see that this means much less time than the colleges assume we have.

The figures given below are taken from the official records, and cover only the scheduled holidays, and time lost by reason of storms. Therefore, they are higher than the net results would show. But as such, they are illuminating.

	TOTAL WEEKS		
YEAR	THEORY	FACT	DAYS LOST
1914-15	39.6	35.4	21
1915-16	39.2	36.0	16
1916-17	39.2	36.4	14
1917-18	36.8	35.4	6 (influenza)
1918-19	38.6	34.4	21
1919-20	37.8	36.4	12
1920-21	37.8	35.0	14
1921-22	37.6	34.6	14
1922-23	38.6	36.0	13
1923-24	39.0	36.4	13
1924-25	38.4	35.8	13
1925-26	22.6	20.4 (incomplete)	11 (to Feb. 19)
AVERAGE FOR 11 YEARS	38.6^{+}	35.6	14^{+}

For the rest of 1925-26 we shall lose at least five days, making 16 for the present year. (Three of these were storms.)

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SECTION A
DIVISION IV OUTSIDE STUDY

A questionnaire from the office was given to all pupils in the early winter, and applied to all subjects. Each department gathered the information, which covered the enrollment in the several classes, the number of minutes of study for the days work--in school time and at home--and a statement of conditions at home for study.

A digest of these answers is given here, by years and divisions. It shows that with all the outside diversions there is some work being done. In Chemistry probably a half of it is spent in writing up a record of the laboratory experiment, or the lecture demonstration. Previous to a written quiz, there is undoubtedly more time put on study.

	DIVISION	ENROLLED	PUPIL HOURS
JUNIORS			
	M.	27	0.71
	R.	16	0.90
	X.	9	0.96
SENIORS			
	F.	30	0.97
	G.	26	0.91
	S.	12	0.66

Divisions M, F, G, are largely made up of pupils who are going on to higher institutions.

(The General Science pupils number 131, and have a group average of 0.53; while the Physiology class which has only five

SECTION A
DIVISION IV

periods a week-no double laboratory-averages o.56)

Practically every pupil reports favorable conditions for home study. One Junior reports spending two minutes a day; a Senior "confusion"; another studies when "traffic" is quiet. She lives on a through automobile route.

I know from observation that many notebooks are written up in "spares"; and that those pupils whose schedule is full take their books home. Fully seventy-five percent of the class have their work done on time, when the confusion of the present year is taken into account. Sports and other outside activity bid strongly for the spare minutes, and those who are leaders in this outside life, are not leaders in school study.

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SECTION B
DIVISION I THE STANDARD MINIMUM COURSE AS APPLIED TO THE YEAR'S WORK

TEXTBOOK**PLAN OF WORK

The text and the laboratory manual used have been those written by Charles E. Dull, published by Henry Holt & Co.; with some laboratory exercises taken from Newell's Descriptive Chemistry and General Chemistry, both of which were used for many years. A complication has arisen this past year which will necessitate some radical change within a year or two. I have yet to find a loose leaf manual that is elastic in its plan, printed on a paper heavy enough to stand up under the wear of constant use; not filled with exercises that are not applicable to the local situation, and therefore a yearly waste of about 60%; and

still a stimulating book.

The work has centered around the laboratory experiment, looking forward to that as the end, and reasoning back to the text from its results. The text is essentially a book of reference, and many a recitation has been staged with the books open, the questions being of local color, with the nucleus of the answer imbedded in the text. Find it and then apply it to the local issue, has been my rule.

The special quantitative work has been done on afternoon assignments, from about January 1st on; some forty pupils returning this year on alternate Thursdays-depending on the teacher to whom they are reciting-and doing about eight experiments. No extra credit is given as far as marks are concerned, it being understood that if they wish to get into College or Normal School they must do this work.

One day a week has been used by the teacher in assisting those who have lost out because of illness, or who have other reasons for needing assistance.

A data slip has been used for the original records in many of the laboratory exercises, corrected by the instructor and passed back for recording in the permanent notebook--with stiff covers. Some experiments permit checking up results as obtained, and then no data slip is passed in--the pupil writing up directly.

SECTION B
DIVISION II AIMS OF THE COURSE IN CHEMISTRY

In explanation of the notes as given in Division IV, it has been my purpose to make the work projective and developmental; an objective sponsored by Frank Wright of the State Board of Education. The character of the environment of the pupil and his background, as given in Section A (Q.V.) have made it certain that when local color is added to pure science, results are forthcoming. As indicated in Division IV, correlation with the every day life of the individual has been attempted, with what success only the future will show.

Every teacher will grant, I think, that the average pupil electing Chemistry today in a city high school has as high standards as ever, is more critical, better informed on the latest things in science as radio, moving pictures, and is anxious to know the whys and wherefores. He or she has to be shown, and when once he or she realizes that there is some excuse for studying a text book will do it. No better method has appeared than to apply the text book to some local situation, as far as possible within the personal experience of the pupil to whom the question may have been put. He is a daily challenge to the earnest instructor, and discipline is not because there is something to be decided.

SECTION B
DIVISION III

SUBJECT MATTER COVERED TO DATE--*SEE OUTLINE OF TOPICS

I have not followed the order as given in the outline in Appendix B, but have adjusted it to meet local conditions. Therefore, the topics may seem unduly separated. Parts of the topics have not yet been covered but will be before June. More detail is given in the list of experiments as done or recommended--see Division V.

WEEK OF	EXPERIMENT DONE	TEXT COVERED
Sept. 18	Laboratory Practice	Definitions Metric System
Sept. 25	Measuring-vol, and weights	Elements, mixtures, Compounds.
Sept. 28-Oct. 2	Physical and Chemical Changes	Changes in Matter
Oct. 9	Oxygen-2 methods	Oxygen
Oct. 16	Fire Extinguishers	Oxygen and Fires
Oct. 23	Hydrogen	Hydrogen
Oct. 30	Fuels and Flames	Fuels-Illuminants
Nov. 7	Reducing and Oxidizing	Carbon
Nov. 14	Decolorizing, Deodorizing	"
Nov. 21	Fractional Distillation Relative solubility	"
Dec. 4	Carbon Dioxide-Monoxide	Oxides of Carbon
Dec. 11	Methane-Methane Series (Lecture Demonstrations)	Hydrocarbons
Dec. 18	" " Hydrometers-Beaume Tables	
Dec. 21-23	Fractionation of Gas Oil " " " "	
	Esters, alcohols	Alcohols-Esters
Jan. 8	Acids, Bases	Acids-Bases
Jan. 15	Salts-Neutralization	Salts
Jan. 18-20	Water of Crystallization Efflorescence-Deliquiscence	Water-elementary

Here second quarter examinations took two days

Jan. 29	Solutions-Crystallizations.	Solutions
Feb. 5	Lecture work from here on for three weeks-broken up by storms and holidays.	
	Electricity-Static and Magnetic, followed by Ionization of Na_2SO_4 with three indicators,-then the Hoffman Electrolysis Tubes, and	

SECTION B
DIVISION III

WEEK OF	EXPERIMENT DONE	TEXT COVERED
	the theory and manufacture of a dry cell and the storage battery.	
Feb. 12	See above for general topics covered.	
Feb. 19	Much demonstration was done, with the purpose of laying a foundation for a realization of the principles of the storage battery and incidently electrons and radio.	
March 12	VACATION OF ONE WEEK Nitrogen	Nitrogen
March 17	Ammonia-some weather work, and reference to refrigeration. (School disorganized by sickness.)	Ammonia
March 26	Nitric acid-and oxides	Nitric acid-oxides
April 2	Sulfur	Sulfur
April 9	Sulfur dioxide and hydrogen sulfide. (Two days out for quarterly examinations.)	Sulfur compounds

(The work from here is planned to go as follows; interrupted by holidays and a spring vacation.)

April 16	Halogens-Chlorine, HCl.	
April 23	Metals-Sodium if time	
April 30	Metals-Sodium and Calcium	
	VACATION	
May 14	Iron	
May 21	Aluminum, Copper, Silver	
May 28	Finish Metals and start Organic-Starches	
June 4	Sugars and alcohols	
June 11	Fats and proteins. Soap, and food values	
June 18	FINAL EXAMINATIONS	

SECTION B
DIVISION III

The special topics as outlined in Appendix B, Part II, have not been taken up as separate work, but have been correlated with the subject matter as seemed most natural. This will appear evident if one only refers to the correlation of topical matter in Division IV.

For example, the place for a discussion of Artificial stone is in connection with a study of calcium not by itself, long after the contact with lime is over. This will be done during the week assigned. The same is equally true of Clay products--take them up when studying clay--aluminum compounds.

Cleaning agents have been referred to in the study of solvents-week of January 29; again during a discussion of the use of sulfur dioxide, and next week in connection with Chlorine.

Coal was covered during fire prevention week, in a study of Fuels and Flames, again in the study of catbon, and the work of the whole month of November.

I will not take time further to show when a bit of correlation between these special topics and the regular work could be done. Undoubtedly it will appear different to different teachers, but I am absolutely sure that if it is to have any lasting value it should be carried along with the regular work.

DIVISION IV CORRELATED TOPICS AS DONE AND PROJECTED

This covers the topics as given in Division III, listing more or less completely the applications and correlations as given or projected during the school year 1925-26. Notes are taken from the actual records of the work as done, with some references to current literature.

The work of the week of September 18th was correlated with the movement on foot to have the metric system adopted as the standard in the U. S.; in view of the fact that Great Britain and the United States are now the only nations where the meter is not the standard. The English system of units was not taught at all.

For the week of September 25th the law requiring Tare and Capacity on all trucks was cited, and interest in volume and weight was thereby stimulated. Different materials were measured and their weight and volume obtained, such as zinc, lead, sand. The present day discussion of the conception of the element was recalled, and the ion was mentioned to be used later.

SECTION B
DIVISION IV

Under physical and Chemical Changes, mention was made of the moving of the glacial drift and sands from Cape Ann across Mass. Bay to Cape Cod,--samples of the sands of the Ipswich Dunes and Cape Cod being shown. The turning back of the Pilgrims when off Chatham because of hard weather, linked up the past of New England with the present.

For several years we have taken up Oxygen and Fire Extinguishing at the time of Fire Prevention Week, and have had no difficulty in arousing real interest. The talk this year of the Deputy Chief before the school Assembly was criticized in the next Chemistry classes.

With Hydrogen, went the reference to the disaster to the Shenandoah, the making of Crisco, in which a former pupil has played a part; the study of flames, and the use of gas for cooking and heating. This came at the time when the coal strike was getting well under way, and naturally enough the first Quantitative experiment was the estimating of the ash in several types of coal and the substitutes. Figures for these are given later, in Appendix C.

The local production of coke, the extensive new Power Plant of the Tenney interests, the arrival of coal and coke from Wales, put Carbon before the pupil clearly, and the laboratory work brought out the principal properties and uses.

In December, following the routine work on Carbon Dioxide, and the local manufacture of Tonics, Bread, and the work of the motor chemicals, the subject of monoxide poisoning in closed garages came up, and there were reports of fatal cases locally and at Harvard. A reading from the current issue of Ind. and Chem. Engineering cleared up the matter of ventilation in the tunnels in New York and Pittsburg, and the use of the latest type of gas mask. (Q. V)

The last of December was utilized to connect up the Hydrocarbons with the local gasoline stations--five of which are visible from the laboratory--with the manufacture of water gas, including the bringing of the gas oil from Beverly to the local plant; the procuring of a quart or more of gas oil, and the fractionating of it as a demonstration before the classes.

With the brief work at that time on alcohol was correlated the new German "Methanol", and the uses for alcohol and "No Vap" in automobile radiators. Since that time a soap concern has supplied an exhibit of their product.

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SECTION B
DIVISION IV

Table salt was made by all pupils, other salts were tested for their chemical water, and the second Quantitative experiment was started. Then solutions and emulsions of several types were made, and working upon the suggestion of a comparison between a "snow storm and a blizzard" two crystallizations were worked out in test tubes from saturated solutions of Ammonium Chloride and Potassium chlorate respectively. The crystals formed slowly and were the talk of the pupils for a week or more; especially so when the snow storms of February made school sessions an impossibility.

Following the half year examinations, in response to questions as to how a storage battery worked and what was the difference between the "A,B, and C Batteries" I put three badly interrupted weeks on the theory of electricity, static, and magnetism, electrolytes and non elextrolytes, correlating here with our previous work on acids, bases and salts; the use of indicators to prove our ionic equations, the electrolysis of a solution of sulfuric acid, and phenolphthalein solution; a discussion of the components of the Ever Ready Carbon Batteries, and of the Ford and Willard Storage batteries; with a complete Willard demonstration set and Radio battery to illustrate the points, parts of a discarded Ford battery, and three sets of Willard folders on batteries and radio. I believe the work was in many cases satisfying,--there were those, of course, who did not and would not wake up.

The week of March 12th was taken up with a study of the usual methods of making Nitrogen, and a discussion of air pressure and the weather. Groups of students from three classes were appointed to make weather ovservations daily for a week for one month, after which the whole class graphed the chart of pressure and temperature.

I propose in the discussion of Ammonia to have pupils report on the Ammonia colling systems in the large stores of the city, at the local hospital, and also to do something with the anthropometric readings as taken by health centers. We have all the necessary equipment.(For lack of time, this was not carried out.)

In the month of March there was a trip to the Hygrade Lamp factory, where the making of vacuum and gas filled lamps was seen. A demonstration set of parts and a set of slides had been loaned to the school and a daughter of one of the Managers described the process previous to a visit to the plant.

In a similar way a trip will be taken to the gas plant to see the making of coal and water gas, and the care taken of the byproducts.

SECTION B
DIVISION IV

The use of chlorine in water supplies has been stressed under the work on the Halogens, and the local figures as compiled by the Water Board referred to, briefly.

The other topics will be tied up as the occasion warrants. The special topics as listed in the Report on Minimum Requirements will be given as far as possible, especially the one on photography, for it is a regular thing to take the class pictures with the school camera, and do our own printing and developing,-at a nominal cost to the pupil. The soap exhibit, mentioned before, will have its day, as will the Welsbach exhibit, and many others collected through the years.

I expect to feel my way in a measure, and take up those things that come up spontaneously in class, keeping, however, within the Requirements.

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DIVISION V

This Standard Minimum Course has no set of laboratory exercises, and in my opinion, it is quite as essential as the other material, especially if the teacher is grouping the work about the experimental. Therefore, I am giving in the following pages a suggestive list of exercises; based on a careful review of eleven laboratory manuals, the authors of which are listed below. To a large extent this represents the work as done this year, and has been checked against the C.E.E.B. and the Minimum Requirements. The authors whose books have been written since 1920 are as follows: Newell-(Practical); Dinsmore; Gray, Sandifur and Hanna; Black and Conant; and Collister and Walrath. Previous to 1920 we have the following: Brownlee and Others; Smith; Blanchard; Godfrey; and Hessler-Smith.

The list as given is for the sake of brevity arranged in groups as before 1920, and since 1920.

A SUGGESTIVE LIST OF LABORATORY EXPERIMENTS

TITLE	C.E.E.B.	MIN. LIST	DONE	TO BE DONE	FOUND IN TEXTS BEFORE 1920	SINCE 1920
Bunsen Burner	0	0	#		2	3
Glass Work	0	0	#		5	5
Phys. Changes	#	#	#		4	5
Chem. Changes	#	#	#		4	4
Oxygen	#	#	#		5	6
Wt. Change on Heating	#	#	#		4	3

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SECTION B
DIVISION V

TITLE	C.E.E.B.	MIN. LIST	DONE	TO BE DONE	FOUND IN TEXTS BEFORE 1920	FOUND IN TEXTS SINCE 1920
Hydrogen	#	#	#		5	6
Water of Crystallization, Efflorescence, Deliq.	#	#	#		3	5
Solutions-S.L.G.	#	#	#		5	6
Distillation-H_2O	#	#		#	5	4
Hard & Soft Water	#	#		#	1	5
Nitrogen	#	#	#		4	5
Carbon Dioxide	#	#	#	#	2	2
Ammonia	#	#		#	5	6
Nitric Acid	#	#		#	4	6
Nitrous Oxide	#	#		#	3	5
Nitric oxide & Nitric dioxide	#	#		#	3	5
Sulphur	#	#		#	4	6
Hyd. Sulfide	#	0		?	4	6
Sulfur dioxide	#	#		#	4	6
Sulfuric acid	#	#		#	5	5
Carbon	#	#	#		4	6
Carbon dioxide	#	#	#		5	6
Carbon monoxide	#	#	#		3	4
Hydrochloric acid	#	#		#	4	6
Acids	0	0	#			
Bases	#	#	#		5	6
Salts	#	#	#		5	6
Neutralization	#	#	#		3	4
Bromine & HBr	#	0		?	4	5
Iodine & HI	#	0		?	4	6
Chlorine	#	#	#		4	6
Replacement & Hydrolysis	#	0		?	0	4
Flame tests	#	0		#	1	6
Cobalt Nitrate	#	0	#		2	4
Aluminum	0	#		#	3	5
Ferrous Iron	#	#		#	2	5
Ferric Iron	#	#		#	2	5
Fermentation	#	#		#	4	4
Esters	#	#	#		4	5
Soap	#	0		?	5	5
Nutrients	#	Optional		#	3	5
Vinegar	0	#		?	-	2
Ions	#	#	#	#	2	6
Boiling Points Freezing "	#	?		?		
Calcium	#					
Qual. 1st group	#	0			2	3
Gas and Air	#	0				
Electroylsis-H_2O	?	#			2	3
Oxidation and Reduction	0	0	#			

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TITLE	C.E.E.B.	MIN. LIST	DONE	TO BE DONE	FOUND IN TEXTS BEFORE 1920	SINCE 1920
Sugars		#		#	5	4
Storage Batteries			#			
Photography		#		#		
**********						
QUANTITATIVE						
Ash in coal			#			
Water in $BaCl_2$ $2H_2O$	#	#	#		3	2
Boyles' Law			#			
Oxygen in the Air	#	#		#	4	5
E Wts. Mg	#	#		#	2	4
" Zn	#	#		#	3	3
" " for AL, Fe. Ag	Optional					
Liter of Oxygen	#	wt. 22.4 1		?	3	4
Titration				#		
Fat test in Milk				#		

Actual numerical results are submitted in Appendix C for the quantitative work. Similar records have been saved for several years back. Results are given for a complete analysis of American and Welsh coals after the method Dr. Newell in his College Chemistry. All these have been the work of pupils.

SECTION C PRELIMINARY SUMMARY

Last September I started in to prove that this Minimum Course was feasible, and to that end read several rather detailed articles on what others thought about tht present situation in Science Teaching. Further I traced somewhat carefully the growth of the present laboratory method of experiment, first, theory second, and as a proof of the results obtained, rather than as a cause of the results.

I have put the outline as given in Appendix B into daily practice, and correlated where possible. Textbooks past and present have been consulted to prove the advisability of certain procedures, and these speak for themselves in Section B, Divisions IV and V. Questions were put to the pupil to get his point of

view, and then the recitation grouped about that answer in the endeavor to put the right idea clearly. Interruption after interruption has nade changes inevitable, and has prevented some topics being taken up as thoroughly as I had planned. Another year something else will cause necessary adaptations. But it must appear evident to my readers that there is cause for some readjustments, if for no other reason than that the several authors quoted are all advocating it. The crucial test question is "WHAT and HOW?"

There have been errors in correlation, and there always will be. Some ideas have been successful in sustained interest, others failed completely-apparently-until in one case a pupil brought in a clipping which showed that he had got the reaction and responded when we least expected it. This was a case which developed after the reading on the clearing of the New York and Pittsburg traffic tunnels of Carbon Monoxide. The clipping showed the ventilating system as installed.

Another illustration is that following a demonstration of a simple lead plate storage battery being charged "while you wait", a member of one of the divisions told of making one for his radio and getting results. The actual battery as used in class demonstration was tested before and after charging with a bell circuit, and delivered current as per schedule. IT WORKED.

One girl who "hates science" but must take it in school or college, has read four or five of the books from the Chemical Foundation, and an elementary book on electricity. She has all

SECTION C (continued)

"A's" in her record for four years, and has just won the valedictorian honors. She is naturally retiring, and artistic in temperament.

Fire prevention week correlated well with the Chemistry work, and that plan will bear repetition. Other "hook-ups" to use a current phrase, have been as successful.

All of which goes to show that Chemistry can be made interesting. And more than that it is the cause of many a pupil finding himself. A study of the graduates of this school shows that many have made good in scientific lines, following their start here.

A question has been put in the final examination for some years as to the most worthwhile part of the year's work, and invariably the answer has been that those parts which showed application to the student's daily life were remembered. Some of these answers are on file and have served as guides for years.

While these topics may be varied in the order of presentation another year, I feel that they are sufficient if rightly handled to fit any one for college or industrial life. The best part of my year's work is ahead, because it will answer the natural questions of the student as to how the life of the city is carried on. Even now I can sense a feeling of interest that is not altogether due to the coming examinations. (Three members of our debating team who went west to Oregon in the May vacation, sent

SECTION C.(concluded).

back accounts of what they had seen that will be used to the advantage of the class in the work on Copper, Silver, Gold, and the other metals.

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CONCLUSIONS.

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SECTION D.

PART I-ACTUAL WORK SUMMARIZED. .

In the preparation of this thesis I have delved into many sides of the question of a Standard Minimum Course in Chemistry for High Schools; and while I am not at all sure that my method of presentation as given here in Section B , Page 19 is the best, I am certain that it meets several of the most urgent needs of the day, and in closing I want to illustrate the actual procedure in one or two cases. From this I hope the reader can get the purpose of the year's work.

J.P. Cooke would not get an audience today with his lectures good as they were. The public wants something up to the minute, and not too dry and philosophical. It must be popular, and not very technical, for in spite of more years spent in school the people are still short of a working vocabulary.

Remsen's Thesis of a few subjects well taught is a forerunner of this Minimum, and today we are still concerned with what

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to teach, or in other words what to leave out. The course must be practical, utilitarian in form,- if theoretical in fact. The twenty eight topics as listed in Appendix B cover a wide range of knowledge, and can be correlated with as much wider a field as the experience of the teacher warrants. The order of presentation is not so important as the attempts made to touch other fields of learning; and yet Carbon must come before Starch, and the elementary gases before the compound ones.

The place for the supplementary topic is with the main topic, not by itself; *if you* are teaching *Chemistry* . The illustrations that follow in this section prove that to my mind.

On page 5 of the Introduction , I made mention of the honor parts going to three pupils who have had Chemistry the past year. These pupils I have come to know rather well, and their statements along with those of others lend color to my conclusions.

Only this last week (May 28) , I gave the available divisions three questions to answer, telling them that they need not put their names on the papers, and that they tell the truth rather than try to please the instructor. They could use the book if necessary to refresh their minds . They *did not* sign the papers, and in the great majority of cases they gave their real feelings. From fifty five answers I am am able to offer the

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following as the view point of the student, -intensely interested in his environment, practical, utilitarian, desirous of knowing why , but in many cases not daring previous to this year to do any thinking for himself. As I have said elsewhere, the minute he can see a use for his knowledge, he is ready to learn , by reading or experiment.

These questions were as follows:

(I) What topic has been most valuable to you the past year? Why?

(2). What topic has been most difficult the past year? Why?

(3). Which type of work do you think gave you the better results-- class discussions or laboratory work?

In answer to the first question Electricity received (13); Carbon (15); Oxygen (17); Earth structures and a study of Sodium , Potassium and Calcium (9). The rest were scattering, where there were special interests ; as for illustration a herd of twenty-two cows, or a garden, foundry experience, and work as an electrician's helper.

In reply to the second question , Electricity received (18); Acids, Bases, Salts,(5); Ionization and Valence(10); Equations (10); Quantitative work (4). Work on the spectra of the alkali

SECTION D.

PART I.

metals , the methane compounds, and the oxides of nitrogen were stumbling blocks in a few cases.

Strangely enough, in answer to the third question , there was a tie,- twenty six each way. This shows that my method of conducting the classes the past year in repponse to the suggestion of Frank Wright of the State Board - namely with the book open on the chair as a source of reference- the questions leading to some outline which I built up on the board as we talked, or a topical outline of the assignment with applications to local conditions at every opportunity, bore fruit. Repeatedly, the answer said that class discussion either cleared up the experimental work , presented all sides of the questions, concerned every day life, or furnished information which they made certain by doing their own work ; also proved their own ideas, taught them to pay attention , and led to clear ,independent thinking.

Very few exercises were put on exactly as given in the manual, materials were purposely changed with different divisions, special parts were assigned one table and not another; some days the reports were on data slips, at other times the last test was checked off by the instructor; and in other ways the work was intensified so that each one had to do his own work. (In Part 2 I shallhave more to say about this question naire,.)

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PART 1.

As a sample of the actual prodedure with reference to one of the topics most successfully taught, I will take the work on Carbon which is outlined on Page 8 of Appendix B, and which in my work was considered from the week of Oct. 30 on through Dec. 4th. (See page 19 of Section B).

Oxygen had been considered, also Hydrogen, and the text takes up next "Fuels and Illuminants. " With the books open, a definition was secured to work on, then the characteristics of a good fuel were discussed carefully(see page 42); the types of fuel were shown the class, and in view of the coal strike which was then well under way, they were carefully considered on their merits,-backed up by home experiences. The pupil forgot that he was studying Chemistry. From that we went on to the nee d of chimneys on the near by factories , and the evident losses of fuel; the tending of the furnace or stove at home; the different types of burners with references to the oxyacetylene torch being used on the railway track work that very week; blowpipe work in the laboratory, doing the cobalt nitrate tests of Dull's manual, and the oxidation-reduction work in Newell. To this was added that most instructive experiment--carbonizing several bits of wood, starch , bone, in a sand crucible and also distilling the same in a closed test tube. During this time Fire Prevention Week was staged locally,

and we used that to drive home the chemistry.

I then turned to the uses of pure carbon in sugar refining, newspaper printing, electrotyping, gas making, with side references to the RevereSugar Refinery , the local News, the Gas Co. (See page 22 of Section B.) Only this week (May 28) we have returned in our discussion to newspaper work, with reference to the metals used in linotyping and stereotyping; and the making of a plaster of Paris mould of two hands of some pupils which has since been baked, and filled with type metal. The veins , and all finger print designs are visible and will serve for a successful project lesson, on a variety of subjects.

When it came to a consideration of CO_2 and CO it was time to refer to our Salem Fire, which eleven years ago in June started within five minutes walk of the laboratory, burned every building between there and the school, then jumped a river and the freight yards for a half mile to continue its destructive work. Thefunction of the 'Chemical' was made plain, and the different types discussed. The traffic over the North Shore Boulevard, with its parking systems, its lanes of gas on a Sunday afternoon, and the consumption of gasoline to produce these gases all came in for an animated consideration. Other applications were made - doubtless, I do not recall them now; but my point is that I make

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the subject alive, and this last questionnaire has shown it. Other correlations were made as indicated on Pages 21-24 of Section B; and as a conclusion of the year's work I am starting the week after Memorial day with a nine day invasion of the realms of food chemistry, with the intention of tying up all the past year's work(I am starting with a discussion of the purpose and structure of a seed, and leading up to the formation of a leaf,its function, and the formation of the carbohydrates. Thus far it is holding the class--(June 2.)

Further suggestions may be found in Section B with reference to other details. While sticking rather closely to the Standard Minimum , I have endeavored to humanize the whole, and I feel that I have succeeded.

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PART II.

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RECOMMENDATIONS.

When it comes to recommending the course, I can do it most heartily, for as I have said elsewhere there is so much interference from outside today that it is absolutely impossible to cover all the material that the C.E.E.B. has thrown together in its requirements, so jumbled that it needs an analytical chemist to separate out the elements. The average pupil in the city school gets his mathematics in spoonfuls, with no explanation of why he is to take it. He naturally opposes its absorption, and comes into

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Science work with no ability to apply ratio and proportion, percentage composition, long division, the decimal system. Thus the more we can be allowed to omit of the old time examination problem the better.

The Section on Law and Theories I have left until the last and am discussing them in the afternoon with those who are to be certified or who are to take examinations. Thus far I find that this plan is working, judging by the report from one special student who says he is seeing the thing as a whole now. Here is one place where I think retardation is advisable,- until the pupil has ground enough to appreciate the meaning of the law.

Electrolysis can easily become too complex. Another year I shall put less time on it,(or at least not all at once.) And yet as recent articles contributed to the Journal of Education maintain there must be some time given to it.

Methyl orange for high school work is confusing. So are the salts other than the neutral ones.

Local color will often save a dull subject , and to that end every teacher should find out where the material to be studied about is used in the town or city; for illustration what buildings are of marble or have marble trimmings; the same of cement; why

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and where chlorine is used in purifying the water supplies; why bromides are essential to the Senior photographs and the moving pictures; if copper and the other metals are found in parts of the country where some student has been-- as the mines just outside Salt Lake City reported on by our Debating Team, and the Cliffs of Gay Head which brought out postal cards from a girl who had been at Martha's Vineyard. The Science section of the Literary Digest is the source of much valuable information if rightly incorporated with the daily lessons.

Etching in my opinion is a subject well included, because of its appeal to the pupil to create something - in Salem we have a very strong Art Department and some famous etchers, whose 'Dry Points ' are known the world over.

The storage battery should be included as should some of the simpler parts of the radio, and the automobile, if for no other use than to point to some application.

PART III. RESULTS FORCASTED.

Properly correlated with his environment, this standard course will give a pupil as fine a background as he can get; upon which to paint future landscapes, or just to enjoy for its own beauty , and dare I say, utility. In this present era which men

SECTION D.

PART III.

of vision are saying is over materialistic, one needs the truth to suport his faith, and here is a chance to fill the young mind with the highest and noblest of ideals, at the same time that the information is made practical. A second Louis Pasteur may be in the making. Only with use will any training be worth while. Make it vital-- then life will be more in the open.

It will be also of immense value if the idea is put across that since time immemorial man has been wandering about the earth, battling with the odds in his environment, from the days when King Tutankhamen directed his slaves in the valley of the Nile, to the latest irrigation project in the "Golden West."Moreover the fact of all nations having a part in progress is patent, inasmuch as we have on the pages of Science the names of Mendelejeff, Pasteur, Priestley, Lavoisier, Von Bunsen, Steinmetz, Boyle, Burbank.

Sections B,C, and D thus far are representative of my methods and my results. They must speak for themselves.

PART IV.

THE HIGH SCHOOL COURSE AND LIFE.

In concluding this thesis , I want briefly to point out the relation between my subject and the whole curriculum of the secon dary school of today. Each subject if worth while should add something to the training of the student, that is distinctive,

SECTION D.

PART IV.

and I feel that Chemistry should produce the ability to think for oneself, really think ; to correlate life outside the school with the text books within;to correlate the life of the individual with that of society, in short to become a worthy member of the true society.

Appendix A has many articles on "How to Make a Live Course"; and the "Seven Cardinal Principles " which have been adopted thruout the states and are being assimilated as fast as possible furnish much inspiration. At the risk of needless repetition I wish to recall these -- Health, Command of Fundamental Processes, Worthy Home Membership, Vocation, Citizenship, Worthy Use of Leisure,Ethical Character. Only by pooling results such as I have secured this year will there be any real advance.

The conditions under which I have worked this past year as given in Section B are not unlike those in many city schools; where changing population, athletics, extra mural activities,social distractions and harassing business ventures aimed to get the money at the expense of the pupil and teacher all bid for the time and interest of the adolescent mind. Truly I wonder that the young people as a group do as well as they do. Sickness, bad weather, holidays and holy days are raising havoc with a schedule grouped a-

round a fixed laboratory period; but the fight is all the more worth while.

The figures given in Section A , Division 3 should convince the most skeptical college professor that forty weeks' work can no more be done in thirty five than a lunar month can be s speeded up to suit some pseudo-scientist. Therefore I offer the plea of Remsen for less material and more breadth in that which is given. In other words, I repeat, more correlation with life.

The Mass. State Board of Education has come out for a course of study that is projective and developmental. This is possible as I have tried it out and I think given sufficient evidence here.

The above list of laboratory exercises as referred to the present C.E.E.B. requirements, to the Standard Minimum , and to the more noted of the text books of the past years, coupled with what I have used and intend to use show what can be done, and what is required. It also shows to what extent the writer tries to meet the requirements of the day.

The several statements of faith, notably that of the steering committee of the A.A.A. S . on Page 8 of Appendix A is a guiding star for those of us who in the lower levels have the more intimate work to do.

To summarize, - Constant reorganization is necessary, with

SECTION D.

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a determined purpose to cut out any growth that is injurious to either pupil or teacher, and in the language of Pasteur to change our belief if the facts justify a change. This will spell true progress, and that is life. Live worthily in our environment and help others to so live. Be broad minded enough however to realize that the individual is entitled to be heard, and in so far as the right is inherent in his view point acknowledge it.

This Standard Minimum is therefore a step in the right direction--Forward.

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SECTION D.

ADDENDA.

I am adding below a statement of the time spent on this thesis to the date given, to which should now be added(May 31) about thirty hours spent in revisions.

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October 6 1925	Consultation with Dr. Newell	0.5 hours.
October 25 "	Outline filed at Graduate School	0.5 "
November10 "	Consultation with Dr. Newell	0.75 "
November 15 "	Preliminary Outline -typewritten	2.00 "
November 16 "	" " mailed	0.05 "
November 17-18	Reading- Twiss:Science Teaching	2.05 "
February 14	" Powers --Notes	6.00 "
February 15-16	Review of Laboratory Manuals	4.00 "
February 18	Stencils on Life Histories	1.00 "
February 19	Compiling data on Life Histories	3.00 "
February 23	" " " "	0.75 "
February 24	Consultation --Dr. Newell	0.75 "
March 3	Compilation of information--	6.00 "
March 5	" "	4.00 "
March 6	" "	4.75 "
March 13	" "	1.25 "
March 13	" "	2.75 "
March 14	" "	7.25 "
		48.25 "

To this in all fairness should be added many hours spent in planning out the work at the school, and in the routine of the laboratory . This means in the region of thirty-five hours a week for the school year.

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APPENDIX A REFERENCE MATERIALS

SECTION I

TWISS, GEORGE R.

SCIENCE TEACHING-----CHAPTER 20

In this chapter, which is upon the psychological basis, Twiss quotes from Thorndike: The Original Nature of Man: as follows:--

"To do something, and have something happen as the consequence, is, other things being equal, instinctively satisfying; whatever be done, or whatever be the consequent happening."

Correlation is not as easy in Chemistry as in the other sciences. As a result the teacher comes to one of two conclusions, namely (I) that it is of little avail to teach chemistry without a large amount of individual laboratory experimentation; (II) that every lesson is an experiment.

With reference to the methods of beginning, Twiss argues that we should not follow the traditional method,--even of the latest textbooks, because we have dropped out largely the Laws and the Atom and Molecule. Rather we should break up the habit of depending for facts on the book, and form the new habit of depending on our observations to furnish a foundation for our judgments. Create a scientific attitude, correlate with the very first and last question, and hold a rapid fire quiz. WHY? Because we should be able to get down to rock bottom. Form memory bonds or associations. (for instance, be able to test with Cobalt Nitrate for Zinc; and then work it out on a Zinc Ointment.)

APPENDIX A

SECTION I

The textbook is a reference book, and as such does not present topics in an order that suggests problems. Therefore, do the experiment, and check through the text book if no clear conclusion is evident.

Teach things capable of application to life, that is, utilitarian. Observe accurately and interpret correctly.

The essentials of a course in Chemistry according to Twiss are as follows: The occurence, preparation, physical and chemical properties of O, H, H_2O, Cl, S, P, N,--the oxides by direct union and the hydration of the oxides to form acids and bases; acids, bases, and salts with the preparation of common commercial salts; varying solubilities; carbon, and its compounds with Oxygen and Hydrogen--(simple ones)--Ammonia, common metals, reduction. (These topics coincide well with the Standard Minimum Course. See Appendix B.)

Correlate with geography, biology, physics--especially energy changes. (The writer believes energy changes are largely chemical.)

With reference to teaching the Laws and Theories, Twiss cites several writers, especially Armstrong: The Teaching of the Scientific Method."

Give percentage composition when introducing compounds,--as in the study of the Hydrocarbons. (Q.V.) Prove in advance Gay Lussac's Law by the oxidation of sulfur (see McPherson and Hen-

derson.)

TWISS, Geo. R.

SCIENCE TEACHING-----CHAPTER 20 (continued)

Teach Boyles' Law and Charles' Law as a means to an end.

Use equations from the very first, and use names and composition by weight.

In the concluding pages of this chapter the author gives many references which are repeated here in the section on Bibliography.

TWISS: CHAPTER 21

PRACTICAL SUGGESTIONS

(1) Begin with facts of observation and experimentation, and stick to it.

(2) Withold laws until ready.

(3) Apply laws to every new case.

(4) Withold theories until needed to explain facts.

(5) Do not memorize only the laws, word for word.

(6) Develop strongly the type reaction.

Careful attention to the types of reaction would result in a much more pedagogical arrangement of the subject matter than is found in many texts--simplest first, then work up. Each teacher must go over all the possible methods of approach and choose the problem that arouses the most natural and real interest.

APPENDIX A

SECTION I

Community applications such as the following will vitalize the work; prevention of industrial waste, chemistry of flames, raising of bread and biscuits, respiration, digestion, fermentation, sanitation, drying paint, mortar and cement, glass making and working, soap making, coal and water gas, ammonia, tonic, inks, dyes, and varnish; alcohol, vinegar, oils, petroleum products, soils, fertilizers insecticides,---.

EXPERIMENT and demonstrate constantly--illustrate your ideas.

****

CHAPTER 24

EXAMINATIONS AND TESTS

Daily recitations and oral tests are wholly subjective--the teacher's conception. Questions may well be too difficult; rating is subjective. Keep a card file of examination questions, answers and ratings (see special notes.) Notebooks may be worth 1/4, laboratory conduct 1/4, recitation 1/4, examination 1/4.

On Page 131, Twiss makes the following suggestions on classroom and laboratory procedure:

(1) Answer some question.

(2) Correlate carefully.

(3) Compel careful observation.

(4) Not too complicated work.

(5) Easy for the poorest.

APPENDIX A
SECTIONI

(6) Fairly accurate.
(7) Cross check.
(8) Clear reasoning in conclusions.
(9) Make drawings from your apparatus.

****

APPENDIX A
SECTION II

POWERS:
SUBJECT MATTER OF HIGH SCHOOL CHEMISTRY
CHAPTER 1. THE PROBLEM AND THE METHOD.

In this detailed study which is a part of a thesis required for the degree of Ph. D. at Columbia, Dr. Powers comes out flat footed for a thorough re-organization of the content of the chemistry course, because

(1) Much of the subject matter is archaic.
(2) The work does not conform to the best educational theory.
(3) There have been enormous changes in the social and economic order, in the subject matter, and in high school enrollment. A large percent of failures in Algebra and Latin show an influx of pupils of lower intellectual levels. Even in elective courses there are many failures; and as a result there is coming an intensive, curriculum reconstruction.

Over 100 test items were used in proving his hypothesis, namely that the task set is too large; and that it is poorly mastered. Eight major questions were raised and as these are answered in the main paper, will be given only once. His method was to give these test items in different schools; score them objectively, and have them given in such a way as not to interfere with school routine.

His results were measures of the ability of the student; and the value of the subject matter. One purpose of teaching subject matter is to develop the ability to acquire information. If pupils in different schools are failing to learn the material then it is too difficult or the method of presentation is ineffective.

In Chapter II there are given seven tables carefully worked out which show that valence is an appropriate subject; that failures in a question on elements, mixtures and compounds was because of a lack of knowledge of illustrations rather than the terms; that definitions should be worked out while on the subject matter; that brief biography had a place; that most pupils are woefully deficient on applied chemical changes,- as for example the make-up of cement, or refrigeration by use of liquid ammonia. This last result is said to show that correlation was not attempted or at best poorly done. He favors teaching equations by teaching those that run to completion;

APPENDIX A
SECTION II
POWERS:
i:e, those with a colored precipitate; and finds that it is easier to write names from the formulae than the reverse.

Few students possess any ability to write formulas.

The principle of oxidation and reduction is too advanced for high school pupils and at the same time meet college requirements.

The character of the pupil varies depending on whether the subject is required or elective,-also whether they are planning to go further or just manage to graduate.

In conclusion, Powers admits the task too great, and states that some schools were so low in their standards as to make it futile to teach Chemistry at all.

CHAPTER 4

In answering the question as to whether the items of the tests were representative of the subject matter of the text book, he cites twelve schools, seven of which used Brownlee, Fuller and others; McPherson and Henderson, three; 2-Dull's Essentials.

In the majority of the classes the textbook was the only source of information. Fifty percent correctness was adopted as the standard for departure. Questions bases on Exercises 51--60 of Brownlee's Manual were used; and in the same manual Exercises 31--50 require 36 equations. Easy maybe, yet not over 25% were answered correctly by 50% of the students.

Further questions on equations and mathematical problems proved that the pupils were not able to do the work. As a conclusion to this part Powers states, "It follows that a large proportion of the textbook material means little or nothing to 50% of the students who have studied one of these texts in High School for one year."

CHAPTER 5

The information is rapidly forgotten, as the tests taken by Freshmen at the University of Minnesota show: because it is done for the teacher. Those pupils who tried the test after five years out of school answered only 19% of the questions correctly. They remember best elements, mixtures, compounds; forget equations early, and formulas nearly as quickly. None have any biographical knowledge. Scores based on Engineering students were slightly higher, an argument for the functional side of Chemistry.

Therefore much of the instructional effort in high school work is misspent, for it is soon forgotten.

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SECTION II

POWERS (concluded)

CHAPTER 6

No great superiority is seen in those students in the University who have had Chemistry in High School over those who did not. Equations and formulas still bother, and are not taught. Statistics again bear out the conclusion that much of the effort is in vain.

CHAPTER 7

Here it is maintained that what Pres. Francis Wayland of Brown University said in 1854 is still true; namely that the average students were illustrations of those "Whose whole knowledge consisted in the remembrance for a few weeks of some of the terms of chemical nomenclature."

Thus, the facts bear out his contention--that reorganization is necessary. The directive forces have not been relating chemistry to the needs of the pupils who study it. Textbooks (I suppose he bases this on the three cited above) are carefully prepared catalogs of facts and principles. The main objective has been preparation for college, guided by the demands of the college authorities.

The second main objective--a clear idea of the principles of Chemistry, and its applications--is not realized; and if it were, it might be of doubtful value. No one of the three books cited has produced the results as intended in the author's preface.

Therefore, a serious study is necessary to determine what kinds of experience, knowledge, habits the young people of today have as a background; what they need to know about science. Then organize these materials into teachable units. Correlate teaching units with life, and results will be more evident.

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APPENDIX A
SECTION III

(a) BIBLIOGRAPHY OF SCIENCE TEACHING IN SECONDARY SCHOOLS
U. S. DEPARTMENT OF THE INTERIOR--BUREAU OF EDUCATION

(Compiled by Earl R. Glenn and Josephine Walker, of the Lincoln School of Teachers College, Columbia University, New York.)

BULLETIN 1025 Number 13

This bulletin is an exhaustive study of source material, carefully compiled and cross checked, and should be valuable to

APPENDIX A
SECTION III

all teachers for years to come. It covers Science in general, then the four special sciences, and concludes with a list of periodicals. One or two of local circulation were not available, as the reports of the N.E.A.C.T. and the E.P.T.

In the preface, the steering committee of the A.A.A.S. outlines the purpose of this work, and emphasizes the fact that the "newer subjects and materials are generally characterized by social and personal as well as vocational value. -- The content, the established conclusions, and the safe guides in thinking of modern science can not be left out, even if some may regard such omission as more or less desirable. The general public education is as much concerned with these problems as are the school authorities. -- We have faith to believe--that established truth is the safe guide for thought and action."

SCHOOL SCIENCE AND MATHEMATICS (*)

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PART III

The following text books have been frequently consulted in the preparation of a lesson or in parts of this paper, and are listed for reference purposes. Other books are available, so that this is not complete.

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Treadwell and Hall: Qualitative and Quantitative Analysis (2 vol.)
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Allyn: Chemistry in the Kitchen.
" Elementary Applied Chemistry.
Olsen: Food.

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SECTION IV
PART I REVIEWS OF SEVERAL STATE AND NATIONAL BULLETINS ON REORGANIZATION.

MANUAL FOR HIGH SCHOOLS.

The original draft of this bulletin was prepared by Clarence D. Kingsley, at that time State Supervisor of Secondary Education for Massachusetts.

Basing its arguments largely on the points given in the "Cardinal Principles", this bulletin favors the comprehensive high school, whose purpose is said to be "To discover and meet the important educational needs of all pupils of high school age; living within the contricuting area. (see Card. Prin. Section XVI.)

The recitation periods shall be in the aggregate approximately 120 sixty minute hours, with the laboratory period counting as one recitation period.

The Commission recognizes the seven main objectives of education, which are given under the review of that bulletin to avoid needless repetition.

APPENDIX A
SECTION IV
PART I (continued)

Therefore, in building up a chemistry course such as the STANDARD MINIMUM, the topics should cover these seven objectives; by correlation in the minds of pupil and teacher alike.

Each child in proportion to his capacity should be guided in his preparation for life.

All education requires an apperceptive basis, hence teachers must know the previous experience of their pupils. (But it is not advisable to know their failings--their good points will be of far more value.)

ALL should have at least one half year of General Science, and as now, should have a course in Physics and Mathematics before taking Chemistry. This will insure promotion from year to year, and ultimate graduation with success.

PART II CARDINAL PRINCIPLES OF SECONDARY EDUCATION

"Secondary education should be determined by the needs of the society to be served, the character of the individuals to be educated, and knowledge of educational theory and practice available. "Constant revision is vital to the continued existence of the desire to know.

"The responsibility of the secondary school is still further increased because many social agencies other than the school afford less stimulus for education than before.---These changes in American life call for extensive modifications in secondary education.

The character of the secondary school population has been modified by the entrance of large numbers of pupils of widely varying capacities, aptitudes, social heredity, and destinies in life--many pupils do not complete the full course but leave at various stages of advancement. The needs of these pupils cannot be neglected, nor can we expect in the near future that all pupils will be able to complete the secondary school as full time students. Of those who enter the four year high school fewer than one third are graduated. The purpose of democracy is so to organize society that each member may develop his personality primarily through activities designed for the well being of his fellow members and of society as a whole.--Consequently, education in a democracy both within and without the school should develop in each individual the knowledge, interest, ideals, habits, and powers whereby he will find his place and use that place to shape both himself and society toward ever nobler ends."

APPENDIX A
SECTION IV
PART II (continued)

THE SEVEN OBJECTIVES

1. HEALTH

"Health needs cannot be neglected during the period of secondary education without serious danger to the individual and the race. The secondary school should, therefore, provide health instruction, inculcate health habits, organize an effective program of physical activities, regard health needs in planning work and play, and co-operate with home and community in safe-guarding and promoting health interests."

2. COMMAND OF FUNDAMENTAL PROCESSES

"Proficiency in many of these processes may be increased more effectively by their application to new material than by the formal reviews of the seventh and eighth grades."

3. WORTHY HOME MEMBERSHIP

"This objective applies to both boys and girls. Home membership should not be thought of solely with reference to future duties.--For girls planning to enter higher institutions, the Committee quotes from a Report on the Articulation of High School and College, 1911, as follows: Our traditional ideals of preparation for higher institutions are particularly incongruous with the actual needs and future responsibilities of girls. It would seem that such high school work as is carefully designed to develop capacity for, and interest in, the proper management and conduct of a home should be regarded as of importance at least equal to that of any other work.

The writer quotes the above because of its suggestive note for a real course in Chemistry.

4. VOCATION

"Vocational education should equip the individual to secure a livelihood for himself and those dependent on him, to serve society well enough through his vocation to maintain the right relations toward his fellow workers and society, and as far as possible to find in that vocation his own best development."

APPENDIX A
SECTION IV
PART II (continued)

5. 6. 7.

CITIZENSHIP, WORTHY USE OF LEISURE, and ETHICAL CHARACTER are the other objectives, and as they are so evident I am not quoting here with reference to the same.

Page 19-20

In view of the important role of secondary education in achieving the objectives essential in American life, it follows that the higher institutions are not justified in maintaining entrance requirements and examinations of a character that handicap the secondary school in discharging its proper functions in a democracy.

****** The worthy use of leisure calls for course in literature, art music, and science so taught as to develop appreciation.***

This most remarkable bulletin closes its pleas for sanity in the schools, by stating that "the physical, intellectual, emotional, and ethical characteristics of young people are still but vaguely comprehended.---Plans must be adopted for the pooling of the results of successful experimentation on the part of individual teachers. It is the firm belief of this commission that secondary education in the United States must aim at nothing less than complete living for all youth, and that, therefore, the objectives described within must find place in the education of every boy and girl."

PART III REORGANIZATION OF SCIENCE IN SECONDARY SCHOOLS

This bulletin goes into minute detail with reference to the general aims and purpose of science teaching, and discusses the seven cardinal principles as the objectives; then turns to the specific values of science stury, such as directive interest work, purposeful activity, informational matters--as in the present radio stage--and the purely cultural. Very carefully it defines what may be gained from each science course, and as the writer of this thesis has taught all the branches he agrees most heartily with the intended results. So much of the material here given has been incorporated in the Minimum essentials that it would seem useless to repeat.

On page 36, the specific science known as Chemistry is considered, and for the benefit of the chance reader I venture to quote at some length, because it is sound backing for a real LIVE course in chemistry.

APPENDIX A
SECTION IV
PART III (continued)

Reorganization, they state is necessary to do away with the age old superstition about matter, to study modern methods of elimination of waste, and attract a much larger number of pupils to the truths waiting to be revealed.

The old order of presentation should be reversed, and the experimental data obtained by the pupil should lead him to formulate the laws of the science for himself. Laboratory first, theory second.

Abstract thinking is so much a part of a successful course in Chemistry, that it should come late in the high school course. Some motive must be present if a pupil is to do his best, and that dan be supplied today from any one of an endless list of applications. "Ultimate causes and reasons appeal to the adolescent pupil."

A PRACTICAL TEST OF THE STANDARD MINIMUM COURSE IN CHEMISTRY FOR HIGH SCHOOLS

APPENDIX B
DIVISION I

TOPICS FOR A STANDARD MINIMUM COURSE IN CHEMISTRY FOR HIGH SCHOOLS

1. WATER

   (a) General Distribution.

   (b) Physical Properties: color, odor, taste, density, boiling point, freezing point.

   (c) Solution: solvent, solution, solute, process of solution, degrees of solubility, factors of solubility, suspensions.

   (d) Impurities in water: what constitutes impurities; purification by boiling, distillation or filtration.

   (e) Crystallization: water vapor, water of hydration, deliquescence and efflorescence.

   (f) Chemical Properties: Quantitative composition of water by electrolysis and qualitatively by synthesis from copper oxide; contrasts of physical and chemical change; contrast of elements and compounds; stability of water; interaction of water with active metals; order of activity; interaction with oxides.

2. OXYGEN

   (a) Preparation.

   Electrolysis of water.

   Industrial.

   Potassium chlorate (use of catalytic agent.)

   (b) Properties.

   Physical: color, odor, solubility in water, weight relative to air, weight of 22.4 liters.

APPENDIX B

OXYGEN

Properties:

Chemical:- tendency to form oxides in air and in oxygen, explanation of oxidation and combustion, kindling temperature.

(c) Uses: necessary to life.

3. HYDROGEN

(a) Preparation.

Electrolysis of water.

Industrial.

Action of certain metals--i:e. sodium on water.

Replacement in acids by metals.

(b) Properties:

Physical: as with oxygen.

Chemical: burns in air, reduction by hydrogen.

(c) Uses (practical): oxyhydrogen blow-pipe, balloons, hydrogenation of oils.

(d) Hydrogen peroxide, properties and uses.

4. LAWS, HYPOTHESES, AND THEORIES.

(a) Law of Conservation of Mass.

(b) Law of Definite Composition. (proportion)

(c) Atomic Theory including electron. (simple treatment)

(d) Law of Boyle and Law of Charles, treated briefly with special reference to gases, not experimentally, but rather their application to the interpretation of change of volume.

APPENDIX B

LAWS, HYPOTHESES, AND THEORIES.

(e) Law of Gay-Lussac and Avogadro's Hypothesis.

5. SYMBOLS, WEIGHT, VOLUME RELATIONS, AND CHEMICAL CHANGES.

(a) Atomic weights, (not their derivation), use in performing simple chemical calculations.

(b) Molecular weights as explained by the Law of Gay-Lussac and Avogadro's Hypothesis.

(c) Symbols and formulas, their meaning and use in writing equations.

(d) Valence with special reference to writing formulas.

(e) Equations and their use in expressing chemical changes, including gravimetric and volumetric equations.

(f) Problems involving (1) percentage composition; (2) weights of substance and volume of gases concerned in chemical relations, and (3) the law of gases.

(g) Kinds of chemical changes: (1) Oxidation and reduction as illustrated by direct combination, decomposition, simple replacement, (substitution), (2) double replacement (metathesis.)

(h) Energy change treated qualitatively; heat; light, electrical energy.

(i) Formulas and the writing of equations for reactions already studied.

APPENDIX B

6. AIR

(a) Percentage of oxygen and nitrogen by volume.

(b) Tests for water vapor and carbon dioxide.

(c) Liquid air: Principle of preparation and source of oxygen and nitrogen.

(d) Two proofs that air is a mixture and not a compound.

7. NITROGEN

(a) Occurence.

(b) Properties.

Physical:

Chemical: nonsupporter of combustion, general inactivity, negative tests.

(c) Nitrogen fixation, as illustrated by plants, synthesis of ammonia, and oxides of nitrogen.

(d) Uses-practical.

8. OXIDES OF NITROGEN

(a) Nitric Oxide: preparation, properties, tests and uses.

(b) Nitrogen dioxide; preparation, properties, tests and uses.

9. NITRIC ACID

(a) Preparation

Indistrial (from the air)

Sodium nitrate with sulphuric acid.

(b) Properties:

Chemical: action of dilute and concentrated nitric acid on copper and silver, test for nitric acid, or a nitrate, decomposition of different nitrates.

(c) Uses: oxidizing agent, nitrocellulose industries, high

APPENDIX B

NITRIC ACID

explosives (briefly)

10. AMMONIA

(a) Preparation

Decay of animal matter (nitrogenous)

Industrial (Haber process.)

Destructive distillation of soft coal

Action of ammonium salt with nonvolatile base.

(b) Properties

Physical

Chemical: Basic character of water solution, ammonium radical, formation of ammonium salts, test.

(c) Uses: refrigeration agent, preparation of ammonia water.

11. ACIDS, BASES, AND SALTS

(a) General Properties: taste, action on litmus, etc.

(b) Solutions, conductors of electric current.

(c) Activity of acids and bases.

12. THEORY OF IONIZATION

(a) How theory explains electrolysis.

(b) How theory explains neutralization.

(c) Acid and base defined in terms of ions; test for hydrogen ions and hydroxyl ions.

(d) Atom and ion distinguished.

APPENDIX B

13. SULFUR

(a) Occurence.

(b) Extractional: American Method (Frasch)

(c) Allotropic forms: Crystalline and amorphous.

(d) Properties

Chemical: Direct combination with metals, for instance, iron and copper.

(e) Comparison with oxygen.

(f) Uses: Vulcanizing rubber, making matches, making sulfur dioxide.

14. SULPHUR DIOXIDE

(a) Preparation: burning sulphur, roasting of sulfide ores, action of an acid on a sulfite.

(b) Properties

Physical

Chemical: action with water, (sulfur dioxide test)

(c) Uses: Bleaching, reducing agent, as a refrigerant.

15. SULFURIC ACID

(a) Preparation

Contact process.

(b) Properties

Physical: specific gravity and boiling point.

Chemical: Affinity for water dilute acid on metal and concentrated acid on copper, test for sulfate ion.

(c) Uses: preparation of other acids, with reason for the same, manufacture of fertilizers; refining of petroleum, pickling of metals.

APPENDIX B

16. HYDROGEN SULFIDE

(a) Preparation: ferrous sulfide and dilute hydrochloric or sulfuric acid.

(b) Properties

Physical

Chemical: Combustion, action on metals, on metallic salts in solution.

17. HALOGENS

CHLORINE

(a) Preparation: one industrial method (electrolysis of water solution of sodium chloride); one laboratory method (oxidation of hydrochloric acid using manganese dioxide.)

(b) Properties

Physical

Chemical: direct combination with other elements to form chlorides, tests, comparison, with oxygen.

(c) Uses: Bleaching and disinfecting action.

(d) Compound: hydrogen chloride (the gas), and hydrochloric acid (the solution)

Preparation: From a chloride and sulfuric acid.

Properties

Physical

Chemical: A typical acid shown by taste, action on litmus, and reaction with metals and bases; test for the chloride ion.

Uses: as a laboratory reagent.

APPENDIX B

18. CARBON

(a) Occurence.

General distribution.

Allotropic forms: diamond, graphite, amorphous forms.

(b) Commercial preparation of useful forms: graphite, charcoal, lampblack, coke, bone-black.

(c) Properties

Physical

Chemical: Affinity for oxygen; action with calcium and silicon (electric furnace.)

(d) Uses: common fuels containing carbon or carbon compounds, operation of household stoves and furnaces, reduction by carbon, decolorizer, absorbent.

19. CARBON DIOXIDE

(a) Occurence : relation to plant and animal life.

(b) Preparation: burning carbon or a carbon compound, action of acid on a carbonate.

(c) Properties

Physical

Chemical: nonsupporter of combustion, action with soluble hydroxide, brief treatment of its solubility in water, temporarily hard water, its role in nature, plant growth, and test for the carbonate ion.

(d) Uses: refrigerating, beverages, fire extinguishers, leavening agent in bread making.

APPENDIX B

20. CARBON MONOXIDE (TEACHER'S DEMONSTRATION)

(a) Preparation; from oxalic acid reduction of carbon dioxide by carbon.

(b) Properties

Physical

Chemical: combustibility, reducing power.

(c) Uses: Reducing agent industrially, constituent of water gas, coal gas, and producer gas.

(d) Illuminating and fuel gases: manufacture and uses.

21. METALS IN GENERAL

(a) Definition of metal, non metal, mineral, ore.

(b) Occurence: free combined.

(c) General methods of extraction, roasting of non oxide ores, reduction of oxide by carbon, electrolysis of chloride, hydroxide or oxide.

(d) Action of air, water (including steam), and dilute acids on the common metals.

(e) General methods of preparing metallic salts: neutralization of acid plus metal, acid plus salt of a more volatile acid, acid plus metal oxide, or acid carbonate.

22. SODIUM

(a) Preparation

Industrial: electrolysis of sodium hydroxide.

(b) Properties

Physical: metallic lustre, hardness, color, power to conduct electricity, and heat.

APPENDIX B

22 (continued)

Chemical: flame test, action with water, with chlorine.

(c) Compounds of Sodium.

Hydroxide: commercial preparation (electrolytic process); properties as a typical base; use (cleansing agent-soap making.)

Chloride: occurence in sea-water and earth's crust; purification and use.

Carbonate: preparation by the Solvay process; properties, uses, active principles of baking powders.

Nitrate: occurence, properties, uses.

Flame test.

23. CALCIUM COMPOUNDS

(a) Carbonate:

Occurence: marble, limestone, shella.

Properties: solubility in water containing carbonic acid; (temporarily hard water); decomposition by heat; action with acids.

Industrial uses: building material; making of quicklime, flux in iron furnaces; glass.

(b) Oxide: preparation (industrial), properties; uses; its hardening.

(c) Hydroxide: preparation, properties, uses, mortar.

(d) Sulfate: Occurence; properties; test; uses; permanemtly hard water and contrast with temporarily hard water.

(e) Bleaching powder: commercial preparation; uses (bleaching-disinfecting.)

APPENDIX B

23. (continued)

(f) Calcium phosphates: Occurence, preparation of fertilizers.

(g) Fertilizers: presence of potassium, nitrogen, and phosphorus as ingredients.

24. IRON

(a) Metallurgy (extraction from oxide ores--pig iron--blast furnace.)

(b) Cast Iron: Physical properties.

(c) Uses of Cast iron--Castings, etc.

(d) Steel: manufacture (Bessemer, open hearth and electrical processes); carbon and manganese steels with reference to their industrial uses.

(e) Protective coatings to prevent corrosion of iron and steel: tin (tinware), zinc (galvanized iron); nickel plate, enameled ware, paint.

(f) Compounds of iron.

Sulfate: preparation; properties, uses.

Chlorides (ferrous and ferric); preparation (laboratory); properties; uses; ferrous and ferric compounds; oxidation and reduction of iron compounds; change of valence.

25. ALUMINUM

(a) Metallurgy (electrolytic process.)

(b) Properties

Physical

Chemical: action with Hydrochloric acid and sodium hydroxide, amphoteric.

APPENDIX B

25. (continued)

(c) Compounds

Hydroxide: preparation (laboratory]; properties; uses, purification of water.

Sulfate (alum): preparation (laboratory); properties, uses.

(d) Uses: utensils, alloys, electrical conductor.

26. COPPER

(a) Purification by electrolysis.

(b) Electroplating.

(c) Properties

Physical

Chemical: action with air and with acids.

(d) Uses: electrical purposes, alloys.

(e) Compounds of copper

Sulfate; Properties; uses (water purification, fungicide)

27. SOURCES OF ORGANIC COMPOUNDS

(a) Destructive distillation of coal: gas, ammonia, benzene, tar, coke.

(b) Destructive distillation of wood: methanol, acetic acid, charcoal.

(c) Distillation and cracking of petroleum: gasoline, kerosine, vaseline, paraffin.

28. ORGANIC COMPOUNDS, BRIEFLY

(a) Sugar

APPENDIX B

28. (continued)

   (b) Starch

   (c) Acetic acid

   (d) Ethanol (ethyl alcohol)

DIVISION II LIST OF TOPICS FOR SUPPLEMENTARY WORK

These are not to be required for college entrance but to be introduced to add interest to the topics in the required minimum outline and to be selected accirding to local importance and at the discretion of the teacher. (Only suggestions for the teacher.)

Adhesives. Gums, paste, dextrin, glue, casein, water glass (Sodium silicate)

Artificial Stone. Lime, plaster, mortar, hydraulic cement, concrete stucco, plaster of Paris.

Beverages. Charged water, soda, mineral, infusions, tea, coffee, fruit juices (artificial flavors) fermentation.

Clay Products. Brick, pottery, stonewate, chinaware, porcelain.

Cleaning Agents. Acid: oxalic hydrochloric. Alkalies: Sodium hydroxide, soap (emulsification). Special solvents: carbon tetrachloride, benzene. Composition of trade-marked cleaning agent.

Coal. Composition and fuel values of different varieties. Distillation of coal tar, light oil, middle oil, heavy oil, tar, pitch. Relation to dyes and explosives.

Dyeing. Direct and mordant dyes.

APPENDIX B
DIVISION II (continued)

Explosives. Black powder, nitroglycerol, dynamite, guncotton, tri-nitro-toluene.

Fertilizers. Soil fertility, elements needed by growing plant and function of each. Photosynthesis and carbon dioxide cycle. Nitrogen cycle and fundtion of nitrogen fertilizers. Use of limestone and phosphate rock.

Foods: Classification; carbohydrates, fats, proteins, mineral matter. Starch preparation from corn; cooking to dextrin and to paste; hydrolysis to glucose. Sugars: preparation and refining of beet and cane varieties; conversion to caramel; inversion. Fats: olive oil, cottonseed oil, butter, oleomargarine, hardening oils by hydrogenation. Protein: Albumins, casein, gluten, peptones, gelatin, vitamins.

Glass. Manufacture crown, flint, lead, special glasses, coloring of glass.

Ink. Iron ink, organic dye ink, carbon ink.

Leavening Agents. Baking powders (composition and reaction); yeast soda.

Matches. Ordinary and safety types.

Metals. Used for basic purposes, iron, copper, aluminum, lead; for ornament, gold, silver, nickel; for alloys, bronze, solder, type metal, anti-friction or bearing metals, fusible metal, alloy steels; tests for metallic iron.

Nitrogen Fixation. Manufacture by the arc, Haber and cyanamid processes. Relation to fertilizers, explosives and dyes.

APPENDIX B
DIVISION II (continued)

Paint, Varnish, Etc. Oil paints and driers, varnish, shellac, copal, linseed oil, oil cloth, linoleum. Pigments: White lead, red lead, iron oxide, lead chromate, zinc white, lithopone.

Paper. Manufacture treated briefly.

Petroleum. Fractional distillation into burning oils, solvent oils, lubricants, paraffins. Problem of gasoline supply and possible exhaustion of petroleum.

Photography. Blueprints, plates, films, prints, toning, etc.

Poisons and Common Antidotes. Common organic drugs.

Preserving. Sterilizing, pastuerizing, desiccating, pickling by salt and sugar; common chemical preservatives and tests for them.

Refuse Disposal. Sewerage, garbage, fermentation and putrefaction; civic problems; disinfectants and deodorizing agents.

Silicates. Treated briefly.

Textile Fibers. Natural and artificial silk. Wool: scouring, bleaching, felting, etc. Cotton: bleaching, mercerizing, etc.

Wood. Distillation of wood to produce methanol, acetone, acetic acid, charcoal.

DIVISION III Additional Topics

Not to be required for college entrance but to be added if time permits.

Alloys, other than those containing copper.

Arsenic Insecticide

APPENDIX B
DIVISION III (continued)

Bromine and iodine, treated similar to chloride.

Catalysis

Colloids, common examples and their application

Electromotive series

Electronic structure of matter, simple interpretation

Gold

Hydrogen equivalent (reacting weights not atomic weights)

Hydrogen sulfide with special reference to treating for certain metals.

Iron Compounds: Oxides, hydroxides, and sulfates.

Lead: properties, uses and compounds.

Magnesium: properties, uses, and compounds.

Mercury: properties and uses of the metal and of the chlorides.

Periodic Table.

a. Elements arranged in order of atomic weights

b. Relation of valence to group numbers

c. Gradual transition from metals to nonmetals in passing from Group I to Group VII

d. Variation of metallic nature with variation of atomic weight within the group,

e. Single elements as types of groups

f. Statement of Periodic Law.

Phosphorus: preparation, properties and uses.

Radium and Radio Activities

Rare gases of the air

Silver: properties and uses; relation to photography

Zinc: metallurgy, properties, uses and salts.

APPENDIX B
DIVISION IV

OBJECTIVES

The following objectives governed the committee in its work:

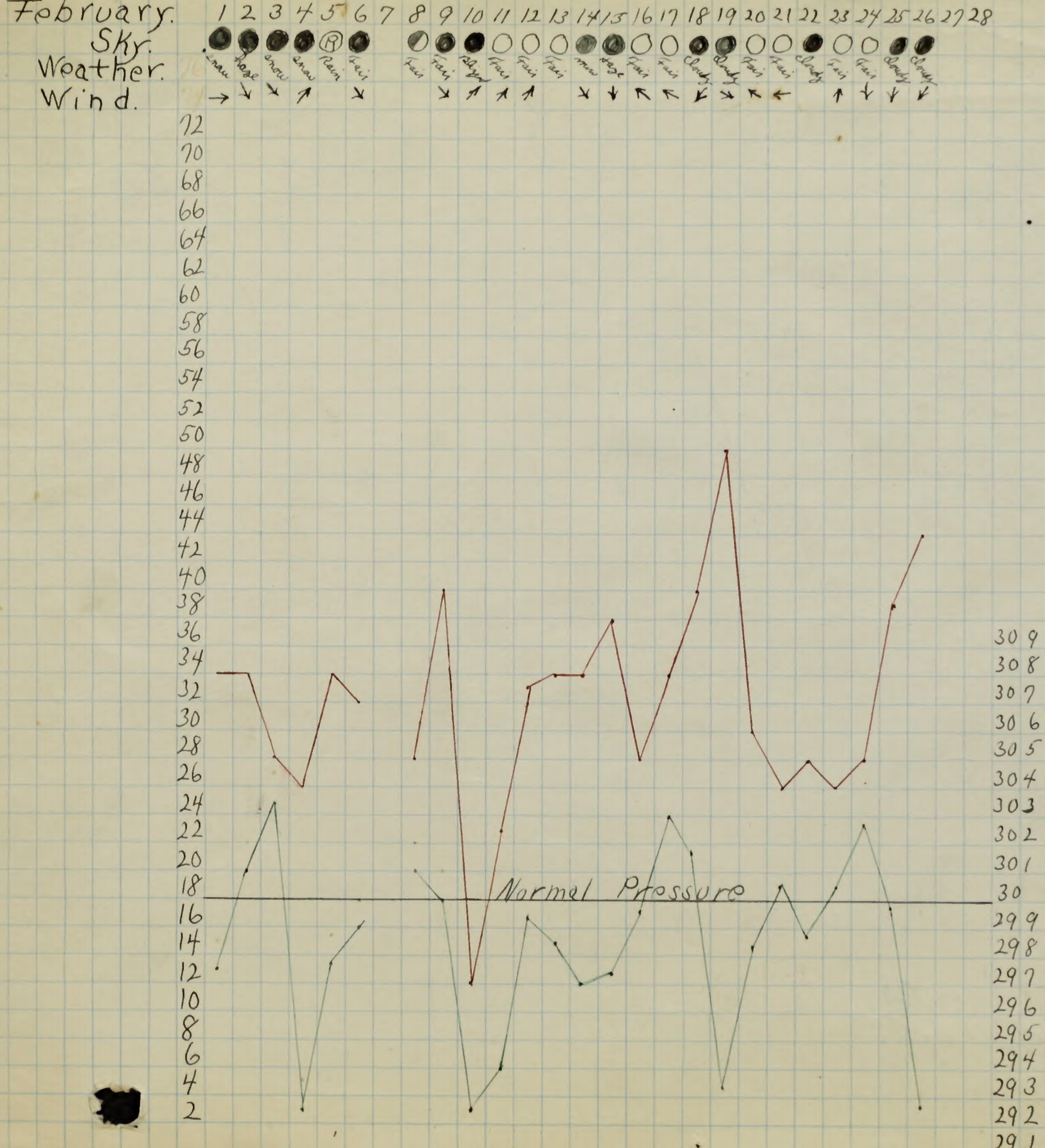
1. To prepare an outline for high school chemistry which is satisfactory for students who wish to get a general knowledge of chemistry as well as for those who are going to college.
2. To list only the minimum essential topics which are common to all localities, so that the high school teacher will have time in developing the course to supplement these minimum topics with material which he considers especially suitable for his locality or for the future work of his students. (See list of topics for supplementary work in Division II)
3. To prepare an outline which would cover the essentials of any State requirements.
4. To prepare an outline which would be in tune with the syllabus of the College Entrance Examination Board.

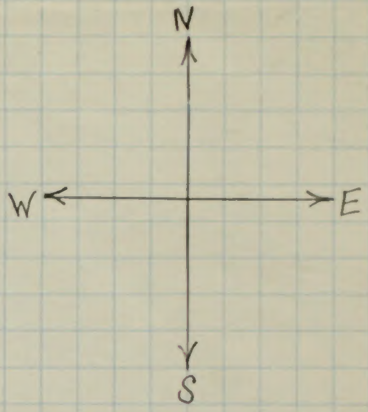
It is the anticipation of the committee that the following objectives will govern the high school teacher in developing the outline:

1. To show the service of chemistry to the home, to health, to medicine, to agriculture, to industry, etc.--in a word, to show the service of chemistry to the country.
2. To develop this service in chemistry around these minimum standard topics, and, in doing so, to see that these minimum requirements are so well taught that they may be built upon as as foundation in dollege.
3. To use his own order of developing the listed topics.

APPENDIX B
DIVISION IV OBJECTIVES (concluded)

4. To train the student in keen observation and exact reasoning.
5. To develop a careful correlation between recitation and experiment.
6. To encourage students to keep notebooks which shall be an accurate record of laboratory experiences expressed in concise, clear, English.
7. To encourage chemistry being placed in fourth year of high school after the students have had a year of general science, and a year of biological science or physics, or preferably both.
8. To build upon the earlier science courses and knit them together in the best possible manner.
9. To encourage students to use reference books in addition to their textbook.
10. To help pupils to find themselves--i. e., to discover whether they have an aptitude for further study in chemistry or applied science, and, if so, to encourage such students to continue their study of science in university or technical school.
11. The teacher is urged throughout the course to stress the general principles involved in the specific cases studied.





Weather Data

February

Taken at 1 O'clock P.M.

—Barometer Reading
—Thermometer "

Archer F Tilton 3/6

APPENDIX C

QUANTITATIVE WORK DONE BY THE PUPILS

The graph of the weather readings for one month as done by one of the pupils is enclosed here in the original. This may be considered more Physics than Chemistry, and yet I contend that to make a study of the Laws of Boyle and Charles with no applications to every day life is wrong. This boy realizes that there is such a thing as a change in barometric pressure, because he has charted it for himself.

During the coal shortage, of last winter, 1925-26-many worked out the percentage of ash in samples of coal, and two worked through a complete analysis after the method of Dr. Newell in his College Chemistry. As a result of a week or more of constant heating and weighing, one of the two arrived at the following figures which are taken direct from his records.

Percentage of moisture	00.647%
" of volatile matter	36.569%
" of Ash	49.514%
" of fixed carbon	13.268%
	99.998%

The above figures were for a sample of cannel coal, of the American type.

A sample of Welsh coal treated inthe same way gave

Percentage of moisture	01.59%
" of volatile matter	11.95%
" of ash	11.95%
" of fixed carbon	74.50%

The official figures for the Welsh"Ovoides" as furnished by the dealer are as follows; making a comparison of pupil and professional work doubly interesting.

	As Received	Dry Basis
Water	4.59%	-----
Volatile Matter	11.62%	12.18%
Fixed Carbon	73.85%	77.41%
Ash	9.94%	10.41%
Sulfur	1.02%	1.07%
B.T.U.	13,075	13,075

(Carried in the Dungeness-N.E.C.& C. CO.; for Pickering from "West Valley" Wales--December 1925.)

APPENDIX C

Other special work would, if given, show that the earnest pupil gets rather good results, and also that he gains confidence in his ability to solve a problem. Such examples of correlation as the above prove, to my mind, the value of applied theory to daily problems.

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